DETAILED DESCRIPTION

[0020] The present invention generally relates to surgical guidance and intra-operative pathology through endo-microscopic tissue differentiation. Embodiments of the present invention are described herein to give a visual understanding of methods for surgical guidance and tissue differentiation. A digital image is often composed of digital representations of one or more objects (or shapes). The digital representation of an object is often described herein in terms of identifying and manipulating the objects. Such manipulations are virtual manipulations accomplished in the memory or other circuitry/hardware of a computer system. Accordingly, it is to be understood that embodiments of the present invention may be performed within a computer system using data stored within the computer system.

[0021] Further, it should be understood that while the embodiments discussed herein may be discussed with respect to tumor resection on the brain of a patient, the present principles are not so limited. Embodiments of the present invention may be employed for guidance and classification for any procedure or any subject (e.g., mechanical systems, piping systems, etc.).

[0022] FIG. **1** shows a system **100** for image guidance and classification, in accordance with one or more embodiments. System **100** may be employed to provide surgical guidance during a medical (e.g., surgical) procedure (or any other type of procedure), such as a craniotomy. System **100** may be located in a hybrid operating room environment where an image acquisition device is readily available during the course of surgery. Elements of system **100** may be co-located (e.g., within a hybrid operating room environment or facility) or remotely located (e.g., at different areas of a facility or different facilities).

[0023] System **100** includes workstation **102** for assisting a user (e.g., a surgeon) during a surgical procedure. Workstation **102** includes one or more processors **124** communicatively coupled to data storage device **122**, display device **126**, and input/output devices **128**. Data storage device **122** stores a plurality of modules representing functionality of workstation **102** when executed on processor **124**. It should be understood that workstation **102** may also include additional elements, such as, e.g., a communications interface.

[0024] Workstation **102** receives pre-operative imaging data **104** of an area of interest **118** of a subject **120**, such as, e.g., a patient. Pre-operative imaging data **104** is acquired prior to a procedure of area of interest **118**. Pre-operative imaging data **104** may be of any modality or combination of modalities, such as, e.g., computed tomography (CT), magnetic resonance imaging (MRI), single-photon emission computed tomography (SPECT), positron emission tomography (PET), etc. Pre-operative imaging data **104** includes high resolution imaging data, such as, e.g., images, video, or any other imaging data. Area of interest **118** may include target objects, such as tissue of a patient (e.g., tumorous tissue), as well as other critical structures. The tissue of the patient may be in-vivo tissue or excised tissue (e.g., biopsied tissue). In some embodiments, pre-operative imaging data **104** also includes pre-operative planning information. For example, pre-operative imaging data **104** may be annotated and marked as part of a planning step. In one example, pre-operative imaging data **104** is marked to indicate tumor margin and important anatomical structures to be avoided. Pre-operative imaging data **104** may be received by loading previously stored imaging data of subject **120** from a memory or storage of a computer system.

[0025] Workstation **102** also receives intra-operative imaging data **108** from image acquisition device **106** of area of interest **118** of subject **120**. Intra-operative imaging data **108** is acquired during an initial phase of the procedure to provide a complete mapping of area of interest **118**. Image acquisition device **106** may be of any modality or combination of modalities, such as, e.g., MRI, CT, cone beam CT, etc. Image acquisition device **106** may also employ one or more probes (not shown).

[0026] Workstation **102** also receives microscopic imaging data **136** from image acquisition device **134** of area of interest **118** of subject **120**. Microscopic imaging data **136** may be received intra-operatively in real-time during a procedure. In some embodiments, image acquisition device **134** may employ one or more probes **114** for imaging area of interest **118** of subject **120**. In one embodiment, probe **114** is an endo-microscopic probe, such as, e.g., a confocal laser endomicroscopy (CLE) probe. CLE is an imaging technique which provides microscopic information of tissue in real-time on a cellular and subcellular level.

[0027] Probe **114** may be instrumented with tracking device **116** as part of navigation system **110** for tracking the position of the tip of probe **114** within the intra-operative imaging coordinate system. Tracking device **116** may include an optical tracking device, an electromagnetic (EM) tracking device, a mechanical tracking system, or any other suitable tracking device. Probe **114** may also include one or more imaging devices (e.g., cameras, projectors), as well as other surgical equipment or devices, such as, e.g., insufflation devices, incision devices, or any other device. In some embodiments, probe **114** may be tracked and manipulated using microrobots or micro-manipulators in combination with navigation system **110**. Image acquisition device **106** is communicatively coupled to probe **114** via connection **112**, which may include an electrical connection, an optical connection, a connection for insufflation (e.g., conduit), or any other suitable connection.

[0028] In one embodiment, pre-operative imaging data **104** may be acquired of area of interest **118** at an initial (e.g., non-deformed) state while intra-operative imaging data **108** and microscopic imaging data **136** may be acquired of area of interest **118** at a relatively deformed state. For example, pre-operative imaging data **104** may include imaging data of a brain of a patient acquired prior to a craniotomy while intra-operative imaging data **108** and microscopic imaging data **136** may include imaging data of the brain of the patient acquired after the craniotomy (i.e., after the opening of the skull). The opening of the skull may result in a shift or a deformation of brain structures (e.g., the tumor and critical anatomy) due to the change in pressure (relative to before the opening of the skull). Other sources of deformation include the natural movement of subject **120** (e.g., breathing), insufflation, displacement due to instruments or devices, etc. These deformations may be located in the abdominal liver, kidney, or any other location of subject **120**.

[0029] Registration module **130** is configured to register or fuse pre-operative imaging data **104** and intra-operative imaging data **108** while compensating for the deformation of area of interest **118**. Registration module **130** computes deformations and shifts of area of interest **118** using a biomechanical model, which simulates or models movement of an organ (e.g., the brain). In one embodiment, the